The comparison brings out that in this region an average of nearly 15 per cent of the area of the national forests has burned over since 1909. The sections west of the Continental Divide have suffered much greater damage than the eastern parts. On the north Idaho forests the fires covered 17 per cent of the area, in northwest Montana 19 per cent, while the eastern sections are all below 8 per cent, some less than 1 per cent. The unusually large area burned over in central Idaho, 43 per cent, is due mainly to the fact that the 1919 fires covered the same ground as the 1910 fires.

The average area per fire in the different sections shows great variations. For north Idaho it is 234 acres, central Idaho 1,154 acres, northwest Montana 281 acres, southwest Montana 130 acres, north central Montana 410 acres, and the rest of Montana less than 100 acres.

This greater fire hazard in the western sections, particularly in Idaho, is due to differences in climatic conditions, particularly rainfall, on the east and west of the Continental Divide. The Idaho sections show high annual and very low summer rainfall, in which respect it conforms to the Pacific coast type of precipitation, while the eastern sections show low annual and comparatively high summer rainfall. In this respect the latter shows its relation to the continental type. Thus the annual rainfall in Idaho averages up to 30 inches, in eastern Montana less than 16 inches; but the July and August rainfall in central Idaho is only 1.40 inches. In eastern Montana it is from 2.43 to 2.92 inches.

The heavy annual precipitation in Idaho gives rise to luxurious forests, with much cedar, hemlock, and fir understory, also much dead and down material. This becomes very dry and highly inflammable in summer on account of the low rainfall and the drying, warm winds coming from the desert region east of the Cascades. These winds blow against the sunny slopes and reach their maximum velocity during the hottest part of the day.

The drier air in the western than eastern sections in summer, and consequently more critical conditions for fires, is shown by an average relative humidity of 25 per cent for Spokane during August, 36 per cent for Kalispell and Yellowstone Park, and 42 per cent at Miles City.

The record shows five years, 1910, 1914, 1917, 1918, and 1919, with serious forest fires, and the remaining five years, 1911, 1912, 1913, 1915, and 1916, fairly free from fires. The bad fire seasons show subnormal spring and summer rainfall, greater than usual amount of sunshine, somewhat higher air temperatures and wind velocities. The average per cent of sunshine at Spokane for July is 77. In July, 1910, it was 88, and in 1919, 89. The average relative humidity at Spokane in August is 25 per cent. In 1910 it was 22 per cent, and in 1919 it was only 16 per cent.

More lightning fires have occurred in central and north Idaho than in the other sections; central Idaho shows a total of 33 per each 100,000 acres in 10 years, north Idaho 23, western Montana 13 each, south-central Montana 2, and southeast Montana 10.8.

The causes of the unusual forest-fire situation during the summer 1919, the worst since 1910, are most likely due to a combination of unusual weather conditions—frozen ground in the fall, so that little moisture went into the ground at the time of melting in spring; much melting of the snow in late December; light winter precipitation; early spring rains most likely fell on the snow in the back woods and therefore did not soak into the ground; very light spring and summer rains. This season, moreover, was the third in a succession of dry summers.

A comparison of climate and fires by months brings out the fact that it is necessary to have at least 2 inches of rainfall for each month in summer to allay forest fires. The average rainfall in the Idaho and western Montana sections are lower than this amount; central Idaho, June, 1.56; July, 0.10; August, 0.70; north-central Montana section shows June, 3; July, 1.72; August, 1.20; south-central Montana, June, 2.46; July, 1.37; August, 1.06 inches.

The most dangerous weather for forest fires occurs at the time of a succession of high-pressure areas over the Pacific Northwest. At such times the air temperature, both maximum and minimum, climbs a little higher each day and the relative humidity reaches very low points.

Climatic records for the last 40 years show a tendency toward periods of very low rainfall each 15 years; the low points were reached 1889, 1904, and 1919; they show also a quite regular drop in the annual rainfall every three years. However, the total annual precipitation does not necessarily mean a bad fire season, for this depends almost entirely upon the summer conditions. It is the combination of low annual, low spring and summer downpour which brings about the unusually bad fire seasons.

The matter of forecasting fire weather in the Pacific Northwest is rendered difficult because there are no fixed points of weather observation to the west of the Pacific coast. Current records, together with past records of fire and climate, must therefore be relied on for the present.

The classification and analysis of the natural conditions set forth in this report are offered, not with the idea that they will help ward off forest fires, but lead to a closer understanding of the natural factors which operate to the destruction of so much valuable timber wealth, dispell certain misleading ideas regarding the relation of climate to forest fires in this region, and serve as a groundwork for later investigations.

DUST SPIRAL NEAR FLAGSTAFF, ARIZONA.

By FERDINAND W. HAASIS.

[Fort Valley Experiment Station, Ariz., March 6, 1922.]

At 1.15 or 1.20 p. m., on June 19, 1920, the writer's attention was attracted by a peculiar sound suggesting an automobile motor. Heard out of doors, the sound resembled the tearing of coarse paper.

Above the forest, due west of the Fort Valley Experiment Station, 9 miles northwest of Flagstaff, a column of tawny dust, the color of the dry soil at that time, was seen traveling in an easterly direction, though with minor deviations, and forming a somewhat undulating band in the general direction of the sun. From below it appeared to be a nearly vertical spiral so close to the sun that the upper part could be seen only with great difficulty. The column was intermittent, sometimes almost wholly disappearing, at which time the characteristic noise subsided also. The height was difficult to estimate; perhaps 500 feet, perhaps 1,000.

When about 500 feet west of the west fence of the station grounds it broke off to the southeast downhill, and whirled around near the back corral. It oscillated on this flat for a time, apparently moving first southeast, then northwest, possibly in a circle, or in other directions. At one time it seemed to be starting to move north or northeast directly toward the station buildings. The